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A Review of The Sources, Accuracy and Availability of The Input Data Required to Run Feyerherm's Spring Wheat Model and Preliminary Testing Performed by Feyerherm

- - Working Paper - -

This Working Paper was prepared as part of the AgRISTARS Yield Model Development (YMD) Project. It is part of Subtask 2 in Task 3 of Major Project Element Number 1 as identified in the 1981 YMD Project Implementation Plan

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INTRODUCTION

In accordance with Research Agreement #58-319T-0-0337X, Dr. Arlin M. Feyerherm has supplied us with the data sets necessary to operate his Spring Wheat Model in North Dakota and Minnesota. The first step in evaluating his model, as part of the AgRISTARS Test & Evaluation program, was to conduct an in-depth review of these associated data sets. We also conducted a review of the model coefficients and predicted yields for the bootstrap test years provided by Dr. Feyerherm. Accuracy, reproducibility and completeness were all important characteristics to be verified. Independent checks on sources were conducted, and data-generating computer programs (WR\PGM'80 and DYAPGM'80) were run. The purpose of this report is to document the results of all our data checks and reviews, comment on problems encountered, and make suggestions where applicable.

Six input variables appearing in Feyerherm's model are defined at the state level. They are:

AVNI	AVE_WX
STYLD_H	AVDYA
FALINC	EE_HLOSS

Some of the variables are composed of other variables defined at the CRD level. All variables, whether state or CRD level, will be defined below.

Also documented below will be the actual comparisons made between Feyerherm's input values and our YES source values. Some of the data were relatively easy to compare, such as the state values for AVNI, STYLD_H and AVDYA. The entire 25 year data set was reviewed in these cases. Other data, such as the CRD components for the other state variables, would require a more lengthy and time consuming comparison. In these cases we elected to draw a random sample of the 25 years (usually only 1/3 to 1/2 of the years) for comparison purposes.

In these comparisons we did not consider mere rounding differences to be discrepancies. Rather, we considered only those differences greater than 1.0 unit of measure and/or greater than 1.0% of Feyerherm's values to be discrepancies needing extra scrutiny. Even these discrepancies may not be "errors", depending upon the type and source of measurement.

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I. AVNI

AVNI = Average amount of Nitrogen applied (lbs/acre)

= (Rate/acre receiving N) * (% of acres receiving N).

Our Sources:

1971-1979 - Fertilizer Situation report, published each year (December-January) by the Economic Research Service (ERS). This data is published as "All Wheat" but it originates from sample fields of the Objective Yield Surveys of the Statistical

Reporting Service (SRS), and both Minnesota and N. Dakota are Spring Wheat only states. Thus, this data is applicable for Spring Wheat. On the average, the # of sample fields is approximately 70-85 for Minnesota and 230-260 for North Dakota. Previous to 1975 Minnesota had an average of only 40-60 sample fields in the survey.

1964-1970 - Cropping Practices report, published June 1971 by SRS. This data also originates with the Objective Yield Surveys of the SRS and so is applicable to Spring Wheat. Average # of fields in the sample were approximately 210-240 for North Dakota and 40-50 for Minnesota over this time span.

1959 - Commercial Fertilizer Used on Crops and Pastures in the United States, Stat. Bulletin #348, published by ERS and ARS (Agricultural Research Service). This data is for all wheat acreage, and originiates from the 1959 Census of Agriculture.

1954 - Fertilizer Used on Crops and Pastures in the United States, Stat. Bulletin #216, published by ARS. This data is for all wheat acreage, and originates from the 1954 Census of Agriculture.

Since the 1959 and 1954 data originated through Census, the fertilizer data may well be for "All Wheat", but probably reflects mostly Spring Wheat. Previous to 1954 data were published in 1947 and 1950 by regions only, but not by states. Prior to 1964 the regional and Census data were the only available data from farm surveys; some states, however, did publish data reported by manufacturers and dealers.

Presently, Fertilizer Situation is published each December. Fertilizer figures for a year, say 1980, actually cover applications from July 1979 (of the previous year) until June, 1980.

Fertilizer figures for a smaller sample unit (CRD or County) are not now available. Objective Yield Survey samples are not statistically appropriate at these levels. Some states do publish total fertilizer consumption by CRD's, but these data are not crop specific, and it is unknown whether Minnesota or North Dakota are among these states.

Comparison to Feyerherm Data:

The entire available data set for AVNI, for both states, were compared to our sources. Differences in rounding did occur, but no discrepancies exist (Table A).

No nitrogen data were available for years 1955-58, and 1960-63. Feyerherm interpolated for these years, and when our source data for 1964, 1959 and 1954 were used, we interpolated the same figures as recorded in his data set.

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TABLE A

Comparison of Feyerherm's Input AVNI Data
(lbs./acre) with YES Check-Data.

Year	N. Dakota		Minnesota	
	Feyerherm	YES	Feyerherm	YES
1954	-	0	-	2
1959	2	2	8	8
1964	4	4	12	12
1965	4	4	12	12
1966	4	4	12*	11*
1967	5	5	21*	20*
1968	5*	6*	30	30
1969	9	9	29	29
1970	10	10	31	31
1971	12*	11*	21	21
1972	13*	12*	56*	55*
1973	17*	16*	49	49
1974	13	13	48	48
1975	14	14	49	49
1976	21	21	59	59
1977	17	17	57	57
1978	19	19	66	66
1979	27	27	69	69

*Differences exist between YES & Feyerherm data, but are not discrepancies.

II. STYLD_H

STYLD_H = All wheat yields per harvested acre.

Our Sources:

We used the following SRS reports for our N. Dakota check-data:

1959-1970 - Wheat Historic Estimates 1955-1970, Ag. Stat. Bull. #33, October 1974, published by SRS,

1971-1975 - N. Dakota Crop & Livestock Statistics Historic Estimates 1971-1975, Ag. Stat. Bull. #43, October 1975, published by ESCS,

1976 - N. Dakota Crop & Livestock Statistics Annual Summary, Ag. Stat. Bull. #42, May 1978, published by ESCS,

1977 - N. Dakota Crop & Livestock Statistics Annual Summary, Ag. Stat. Bull. #44, May 1979, published by ESCS, and

1978-1979 - N. Dakota Crop & Livestock Statistics Annual Summary, Ag. Stat. Bull. #45, May 1980, published by ESCS.

This data contains information for spring wheat and winter wheat separately as well as for all wheat.

Minnesota wheat data are also available in SRS reports, but for our purposes we found it easier to use the data, for both spring and all wheat, which we have stored on file on the Suitland Computer Network.

Both states publish revised and preliminary estimates for spring wheat and all wheat each summer. Thus, 1980 preliminary and 1979 revised data became available in the summer of 1981.

Comparison to Feyerherm Data:

All STYLD_H values for both Minnesota & N. Dakota were reviewed and no discrepancies were discovered.

Spring Wheat Data:

Table B shows a comparison between All Wheat vs. Spring Wheat yields per harvested acre for both states. It can be seen that in North Dakota winter wheat was not even reported before 1964, and that subsequently in only 5 years did yields differ by even as much as 0.1 bu/acre between all wheat and spring wheat. In Minnesota most years did show a difference, but only by 0.4 bu/acre at the maximum.

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III. FALINC

FALINC = Measure of yield differential (bushels/acre) statewide due to following fallow ground cropping practice rather than continuous cropping

TABLE B

Comparison of All Wheat vs. Spring Wheat Yields
(bu./ harvested acre)

Year	N. Dakota		Minnestoa	
	All	Spring[t]	All	Spring
1955	15.2		19.2*	18.8*
1956	17.2		23.7	23.7
1957	18.8		22.6	22.6
1958	23.1		31.4*	31.5*
1959	15.0		22.9*	23.0*
1960	19.8		27.4*	27.5*
1961	12.1		24.0*	23.9*
1962	28.7		24.8*	24.9*
1963	22.3		24.8	24.8
1964	23.8	23.8	23.3*	23.2*
1965	26.0	26.0	27.8*	27.9*
1966	23.4	23.4	22.9*	22.8*
1967	22.6	22.6	32.1*	32.2*
1968	26.8	26.8	32.9*	33.1*
1969	29.8*	29.9*	30.0*	30.1*
1970	23.6	23.6	27.6	27.6
1971	31.8	31.8	37.9*	38.1*
1972	28.9*	28.8*	32.9*	33.0*
1973	27.5	27.5	38.9	38.9
1974	20.4*	20.3	28.9*	29.0*
1975	25.9	25.9	30.8*	31.0*
1976	24.7	24.7	32.2*	32.4*
1977	24.8*	24.9*	39.6*	39.9*
1978	29.8*	29.9*	33.6*	33.7*
1979	26.3	26.3	35.1	35.1

[t]Winter wheat was not reported in N. Dakota until 1964

*Differences exist between All Wheat and Spring Wheat yields.

$$= \{(FL\_1 * INC\_1 * P\_1) + \ldots + (FL\_9 * INC\_9 * P\_9)\} /10{,}000,$$

where:

FL_x = % of all wheat harvested in CRD x which was on fallow ground,

INC_x = Average differences in yields between fallow and continuous all wheat for CRD x, and

P_x = % of the state-wide all wheat harvested acreage in CRD x.

Our Sources:

Data on the above three variables, for N. Dakota, are available in the same source documents listed in Section II for STYLD_H. Data for these variables are available at the CRD or County level, and for spring wheat alone.

For Minnesota, Feyerherm's data for FL_x and INC_x variables were imputed as zeroes. In a review of data sources plus inquiry with the Minnesota SSO we confirmed these zero values. Minnesota has never published wheat data by cropping practices. The state is almost totally continuously cropped, and this is especially so in the Red River districts (CRD 10 & 40).

Our source for P_x variables was the same as mentioned in Section II for STYLD_H. As with North Dakota, these data are available by CRD or county, are updated every summer following the harvest year, and exist for spring wheat alone.

Comparison to Feyerherm's North Dakota Data:

(1) INC_x

To compute these variables, Feyerherm first recorded the yields for continuous cropped all wheat and fallow all wheat, and their differences (Fallow - Continuous), for each CRD/year. These data were punched on cards and run through a computer program which summed up the yield differences over years and calculated an average difference for each CRD over those years. This was first done for the aggregated model development years 1955-1969, and repeated each new year, recalculating INC_x with the addition of another year of data.

We made several checks of the data. First we randomly selected 6 of the 11 years (1969-1979) to see whether the final INC_x values were transferred correctly from the computer printout (a copy of which we were given) directly to Feyerherm's punched card data set. The years selected were 1969, 1970, 1974, 1975, 1978, 1979. No transcribing errors were discovered. (We note here that the values calculated using data up to and including 1969 are used for 1955-1968. We could expect yearly values of INC_x to be slightly different if each year had been calculated separately, though the magnitude of the effect on the final FALINC values is unknown.)

Secondly, a random sample of 8 years was selected in which the actual fallow yields and continuous cropped yields for that year were checked. Table C shows the results of this review. The year 1974 was obviously a problem year. We summarily checked years 1971, 1973 and 1975, but could find no more errors. We concluded that Feyerherm probably did not pick up final revisions made by SRS in years immediately following the Census of Agriculture (as in 1974).

It should be noted that even though 1974 was obviously wrong, in most CRD's the direction and magnitude of the errors were very similar. This means that very little change occurred in the yield differences between fallow and continuous. For this reason, as well as because few discrepancies were found in the other 7 years, we did not think it necessary to modify any of Feyerherm's input data values.

(2) FL_x

The same random sample of 8 years mentioned above for INC_x variables was used for the check-data review of FL_x variables. Results are shown in Table D. Rounding differences were found in 5 of 8 years but only 2 of these differences were considered discrepancies. No modification of the input data was considered necessary.

(3) P_x

The same 8 years mentioned above were checked for P_x errors. Review of these years quckly showed a miscalculation of practically all P_x values. A clerical error in computing had been made; instead of calculating the % of the states all wheat harvested acreage in each CRD, Feyerherm's input data contained the % of the state's fallow harvested acreage in each CRD. This error occurred in every year from 1955-1975. Also, for the years calculated correctly (1976-1979) it was discovered that in 1977 and again in 1979 the summed percentage added up to 99, not 100. For these reasons P_x values for all years, for all wheat data, were recalculated and are listed in Table E.

North Dakota Spring Wheat data:

As stated before, spring wheat data are available. However, prior to 1964 North Dakota did not report winter wheat at all. Thus, FL_x and P_x data for spring wheat in years 1955-1963 should be identical to Feyerherm's all wheat input data over the same time span. These data were recalculated for spring wheat to serve as a check for rounding differences and, in the case of P_x values, summation within a year to 100.

For years 1964-1979 spring wheat values may differ from all wheat. However, because winter wheat makes up such a small percentage of harvested acreage in N. D. (0.5 - 2.0%) we expect these changes to be minimal, and suspect this is why Feyerherm did not consider it important to screen out such data. Table F compares YES source Spring Wheat FL_x values with Feyerherm's all wheat FL_x values. Several differences are noted but, as expected, changes are minimal. Table G lists YES source Spring Wheat P_x values which should be compared to values in Table E. Again, very few changes are noted.

Table C

Differences between Feyerherm's continuous and fallow N. Dakota yields and YES N. Dakota yields. Table values (bu/acre) are results of subtracting Feyerherm's yields from YES yields.

	CRD																	
	10		20		30		40		50		60		70		80		90	
Year*	F	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C
1956							No Differences											
1959							No Differences											
1963							No Differences											
1964							No Differences											
1969	-0.3														-0.1			
1974	+0.1		+0.2		+0.2	+0.5	+0.1	+0.1	+0.2	+0.2	+0.1	-0.1	-0.9	-0.5	+0.2	+0.2	-0.4	-0.5
1977							No Differences											
1979	+0.3																	

*Includes only the 8 randomly selected years.

Table D

Comparison of Feyerherm's Input FL_x Data (%) with YES check-data. 1st number - Feyerherm's %, 2nd number - YES %

	CRD								
Year*	10	20	30	40	50	60	70	80	90
1956				49-54					
1959				59-58					
1963	98-97								
1964				80-79	75-77				
1969			No Differences						
1974			No Differences						
1977				75-76					
1979			No Differences						

*Includes only the 8 randomly selected years

Table E

Listing of P_x data from YES Sources
for N. Dakota All Wheat.
% State Harvested Acreage in each CRD.

Year	CRD								
	10	20	30	40	50	60	70	80	90
1955	16	12	19	9	10	8	11	7	8
1956	17	13	20	9	10	9	7	7	8
1957	15	12	20	10	10	9	9	7	8
1958	15	11	17	9	10	9	12	8	9
1959	16	12	17	10	9	9	11	7	9
1960	15	12	17	10	10	9	11	7	9
1961	15	11	20	9	10	10	11	5	9
1962	16	13	20	9	10	8	9	7	8
1963	16	12	18	9	10	9	11	7	8
1964	16	11	18	9	10	9	10	8	9
1965	17	12	19	9	9	8	10	8	8
1966	17	12	18	9	9	9	11	7	8
1967	17	12	18	10	10	8	10	7	8
1968	17	12	19	9	10	8	10	7	8
1969	18	12	19	9	10	9	9	7	7
1970	18	12	19	9	10	10	9	6	7
1971	17	12	20	8	10	11	8	6	8
1972	17	11	19	8	12	11	8	6	8
1973	17	11	19	8	11	12	7	6	9
1974	16	11	18	8	11	12	8	6	10
1975	15	11	19	8	11	11	8	7	10
1976	15	11	18	7	11	12	8	7	11
1977	16	10	18	8	11	11	9	7	10
1978	16	11	17	9	11	10	9	7	10
1979	16	11	17	9	11	10	9	7	10

Table F
Comparison of Feyerherm's FL x All Wheat N. D.
Data with YES Source FL x Spring Wheat N. D. Data.
1st Number - Feyerherm's %, 2nd Number - YES %

Year	CRD								
	10	20	30	40	50	60	70	80	90
1955	81-81	43-43	34-34	58-58	34-34	39-39	57-57	26-26	15-15
1956	78-78	44-44	41-41	49-54*	35-35	48-48	65-65	22-22	13-13
1957	87-87	57-57	54-54	58-58	46-46	54-54	71-71	27-27	20-20
1958	92-91*	75-75	63-63	61-60*	55-55	61-61	62-62	32-32	24-24
1959	92-92	78-78	70-70	59-58*	58-58	57-57	59-59	31-31	23-23
1960	92-29	74-74	71-71	61-61	58-58	59-59	64-64	26-26	23-23
1961	96-96	80-80	77-77	69-69	64-64	64-64	68-68	41-41	24-24
1962	96-95*	82-82	75-75	73-73	72-72	71-71	72-72	45-45	37-37
1963	98-97*	87-87	90-90	81-81	80-80	79-79	86-86	55-55	44-44
1964	97-97	87-87	88-88	80-79*	75-77	72-72	82-82	51-51	45-45
1965	96-96	88-88	82-82	82-81*	78-78	73-72*	86-86	51-51	42-41*
1966	96-95*	85-85	79-79	81-81	75-75	74-74	86-87*	50-50	42-42
1967	93-93	81-81	75-75	79-78*	70-69*	64-64	85-84*	46-46	39-40*
1968	93-92*	80-80	72-72	78-78	67-67	65-65	84-84	45-45	36-35*
1969	96-96	88-88	80-80	85-85	80-80	75-75	93-93	61-61	47-47
1970	97-97	93-93	83-83	92-91*	86-86	76-76	96-96	71-71	63-63
1971	95-95	86-86	78-78	89-89	77-77	67-67	94-94	68-68	56-56
1972	96-96	87-87	74-74	89-89	75-75	57-57	96-96	74-74	55-55
1973	95-95	90-90	79-79	91-90*	79-79	57-57	96-96	77-77	54-54
1974	88-88	78-78	62-62	81-81	58-58	34-34	87-86*	58-58	28-28
1975	87-87	71-71	57-57	78-77*	51-51	31-31	87-86*	46-46	22-22
1976	82-83*	64-64	49-49	75-74*	47-47	27-27	84-83*	40-39*	17-17
1977	84-85*	69-69	52-52	75-74*	50-49*	24-24	83-83	51-51	23-23
1978	86-86	68-68	52-52	76-75*	56-56	27-27	85-85	51-51	21-21
1979	84-84	68-68	47-47	77-77	53-53	28-27*	85-85	51-51	26-26

*Differences exist between Feyerherm's % and YES %.

Table G
Listing of YES Source Spring Wheat P_x Values,
% of State Harvested Acreage in Each CRD.

Year	CRD								
	10	20	30	40	50	60	70	80	90
1955	16	12	19	9	10	8	11	7	8
1956	17	13	20	9	10	9	7	7	8
1957	15	12	20	10	10	9	9	7	8
1958	15	11	17	9	10	9	12	8	9
1959	16	12	17	10	9	9	11	7	9
1960	15	12	17	10	10	9	11	7	9
1961	15	11	20	9	10	10	11	5	9
1962	16	13	20	9	10	8	9	7	8
1963	16	12	18	9	10	9	11	7	8
1964	16	11	18	9	10	9	10	8	9
1965	17	12	19	9	9	8	10	8	8
1966	17	12	18	9	9	9	10*	8*	8
1967	17	12	18	10	9*	9*	10	7	8
1968	17	12	19	9	10	9*	9*	7	8
1969	18	12	19	9	10	9	9	7	7
1970	18	12	19	9	10	10	9	6	7
1971	17	12	20	8	10	11	8	6	8
1972	17	11	19	8	12	11	8	6	8
1973	17	11	19	8	11	12	7	6	9
1974	16	11	18	8	11	12	8	6	10
1975	15	11	19	8	11	11	8	7	10
1976	15	11	18	7	12*	12	7*	7	11
1977	17*	10	19*	8	10*	11	9	6*	10
1978	16	11	17	9	11	10	8*	7	11*
1979	17*	10*	18*	9	10*	10	9	7	10

*Differences exist between these values and comparable values in Table E.

Comparison to Feyerherm's Minnesota data:

The only variables to check in the Minnesota input data are the P_x. A random sample of 9 years was chosen, and the results of YES source comparison with Feyerherm's data for these sample years can be seen in Table H. Minor differences due to rounding did occur, and in 5 of the 9 sample years Feyerherm's percentages did not add to 100 across a year (4 added to 101, 1 added to 98). None of these were considered discrepancies, and since the P_x values do not enter into the final models (FALINC being set to zero, as mentioned previously), we did not modify Feyerherm's input data set.

Minnesota Spring Wheat Data:

These data are available, as stated previously, but further comparisons with all wheat data were not undertaken.

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IV. AVE WX

AVE_WX (bushels/acre) is a simple average of WX_x values computed for the weather stations associated with each state. WX_x = MOIST + TEMPRE for weather station x. MOIST and TEMPRE are defined in Sec. VII.A. of Feyerherm's "Data Base Documentation for Test Data for KSU Spring Wheat Model," and are linear combinations of weather related variables produced by Feyerherm's computer program WRVPGM'80.

Feyerherm used weather data from two National Weather Service stations (Bismarck, Fargo) and four FAA stations in North Dakota. The data from these six stations was complete from 1955-1979. Therefore, AVE_WX was set equal to a simple average of these six WX_x values each year.

For Minnesota, three of the FAA stations used (Alexandria and Redwood Falls, MN, and Watertown, SD) did not have complete weather data available. Therefore, from 1955-1964, AVE_WX is a simple average of six complete weather stations, while from 1965-1979 it is a simple average of nine weather stations. National Weather Service stations used for Minnesota were International Falls, Rochester, and St. Cloud, MN, Fargo, ND, and Sioux Falls, SD.

Another National Weather Service station (Williston) could have been used in North Dakota. Dr. Feyerherm will be computing and providing us with these WX values. He chose not to use three stations in eastern Minnesota: Hibbing, Duluth, and Minneapolis/St. Paul.

Our Sources:

For purposes of testing the WRVPGM'80 computer program, Feyerherm sent us a tape containing daily weather data in a WBAN Deck 345 format. This tape contained daily weather data for seven weather stations. These stations, with accompanying beginning and ending dates, are as follows:

Table H

Differences between Feyerherm's Minn. P_x values and YES Minn. P_x values.

Table values (%) are results of subtracting Feyerherm's percent from YES percent.

	CRD								
Year *	10	20	30	40	50	60	70	80	90
1956	No differences								
1963	No differences								
1967	No differences								
1971	No differences								
1972	No differences								
1973	No differences								
1974				-1	+1				
1977		-1		-1					+1
1979					+1				+1

*Includes only the 9 randomly selected years.

Alexandria, MN	1/1/49 - 12/31/54 and 1/1/63 - 12/31/76
Fargo, ND	1/1/48 - 12/31/76
Grand Forks, ND	12/1/48 - 12/31/54 and 1/1/63 - 12/31/76
International Falls, MN	1/1/48 - 12/31/76
Jamestown, ND	1/1/49 - 12/31/54 and 1/1/63 - 12/31/76
Rochester, MN	1/1/48 - 12/31/76
St. Cloud, MN	1/1/48 - 12/31/76

Because we did not have weather data for three other North Dakota and three other Minnesota stations, we can not recreate AVE_WX variables for each state. The best we can do is check individual year/station values of the WX_x variables.

From the listing above it can be seen that two of the N. Dakota stations (Grand Forks, Jamestown) had a large gap in the weather data, even though Feyerherm had complete data for developing his model. Feyerherm, however, had filled the gap by obtaining a supplemental tape, covering years 1955-1963, from NOAA through Sharon LeDuc.

It can also be seen that Alexandria actually did have weather data for 1963-64, though these years of data were not used by Feyerherm in his model development. The reason for this was that the Redwood Falls station did not have data prior to 1965 and Feyerherm wanted his three incomplete Minnesota stations to be consistent with one another.

Besides the daily weather tape, the only other needed inputs were the monthly normal maximum and minimum temperatures for all seven stations. Feyerherm provided these max and min's for Fargo along with the necessary Block Data for running WRVPGM'80. For three stations (International Falls, Rochester and St. Cloud) data were obtained on the needed max and min's by calling the National Weather Service in St. Louis. They read the data off of Local Climatological Data publications (LCD's) unavailable here in the NOAA library. The remaining three stations (Grand Forks, Alexandria, and Jamestown) had available max and min's recorded in special publications (Climatography of the United States #20) put out jointly by NOAA, EDS, and NCC, for the smaller weather stations of the U.S. These publications were available here in the NOAA library. Our max and min values are almost certainly different from those used by Feyerherm as he calculated his values from the daily weather data available to him.

Comparison to Feyerherm Data:

For the four complete stations on the WBAN Tape, we ran the WRVPGM'80 program and calculated weather-related variables from 1949-1976. We then drew a random sample of five years from the 1955-1976 period,

calculated WX_x values, and compared these values with Feyerherm's input data values. These results are shown in Table I. No discrepancies occurred at all.

For the three incomplete stations on the WBAN Tape we ran the WRVPGM'80 program for the years 1963-1976. At first we drew a random sample of three years from the period, but we quickly noticed large discrepancies in the earlier years (1963-1966). These discrepancies were as large as 15% in some instances. When we contacted Dr. Feyerherm he told us that he had run the WRVPGM'80 program for all three stations starting in year 1949 and used the contents of the Soil Moisture Budget (SMB) at the end of 1954 for starting values in 1964. When we re-ran WRVPGM'80 using this technique, the large discrepancies disappeared (Table J). It seems that after Feyerherm received the supplemental data for Jamestown and Grand Forks (which held data through 1974), he ran it through the WRVPGM'80 program for the years 1955-1963 but did not re-run years 1964-1974.

Maps 1 and 2 show the locations of the weather stations for both states. These can be compared to CRD boundaries. Since there are fewer weather stations than CRDs in North Dakota, there may be difficulty in deriving CRD models.

Other smaller stations are available for this purpose, but the daily weather data for many of these stations will be incomplete, less accurate, and not available on a timely basis.

In Minnesota, 85-90% of all spring wheat is grown in CRDs 10 and 40, and models for other CRDs may not be critical. The map shows several weather stations in and near CRDs 10 and 40.

Although Feyerherm has chosen to use weather station data which is available on a timely basis, WX could be computed using daily weather data aggregated from climatic division data available for each state. The comparison might illustrate any advantage gained from the use of the denser network used to obtain climatic division weather values.

Additional Observations on WRVPGM'80:

Two small problems became apparent with the running of this program. They are as follows:

(1) To begin a run the starting day (Julian) for the soil moisture budget (SMB) must be specified in a parameter card. However, this starting date must be between 0-19 if the planting date is to be calculated. It seems that in the program there are several specified "IF-THEN" statements which lead to the beginning of the program "clock" (planting day) and the derivation of weather-related variables for different crop calendar dates (heading, milk, etc.). According to the programming statements, if the SMB starting date is greater than 20, then the "clock" never actually begins, and the program will read through the entire tape,

Table I

Differences between Feyerherm's Input WX_x values and YES generated WX_x values (4 complete stations).

Table values result from subtracting Feyerherm's values from YES values.

Fargo		International Falls		Rochester		St. Cloud	
Year	Difference	Year	Difference	Year	Difference	Year	Difference
1955	-0.04	1955	0.03	1958	-0.01	1963	0.03
1956	-0.08	1966	-0.01	1959	0.02	1967	0.02
1959	0.03	1970	0	1963	-0.02	1972	-0.01
1962	0.06	1971	0.04	1967	-0.02	1973	-0.01
1964	0.02	1973	0.01	1968	0.04	1974	-0.01

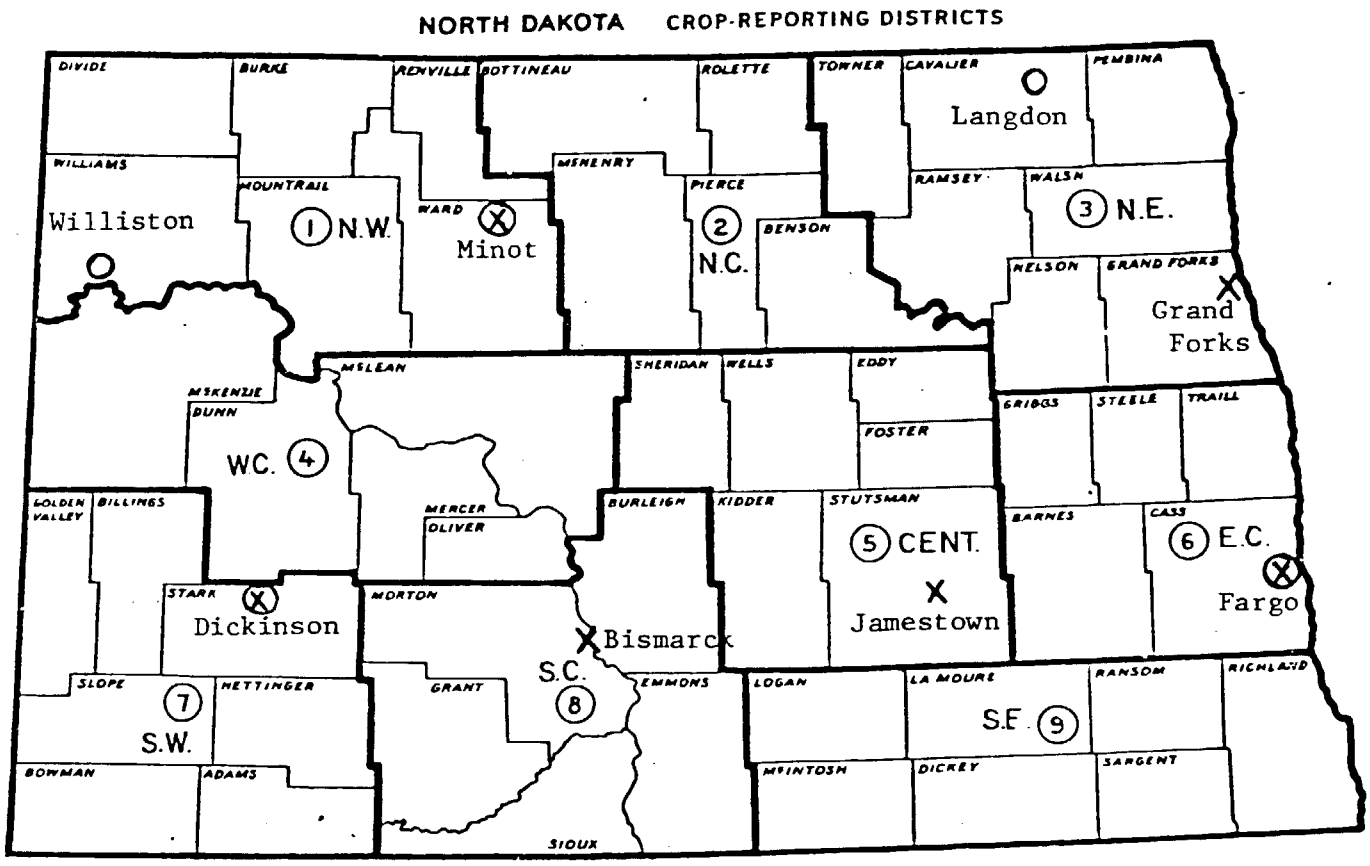
Table J

Differences between Feyerherm's Input WX_x values and YES generated WX_x values (3 incomplete stations).

Table values result from subtracting Feyerherm's values from YES values.

Grand Forks		Jamestown		Alexandria	
Year	Difference	Year	Difference	Year	Difference
1964	-0.20	1964	-0.05		
1965	-0.09	1965	-0.01	1965	-0.01
1966	-0.03	1966	-0.07	1966	-0.03
1967	-0.01	1971	+0.01	1973	-0.04
1968	-0.01	1973	-0.03	1975	0
		1975	-0.02	1976	-0.05

MAP 1

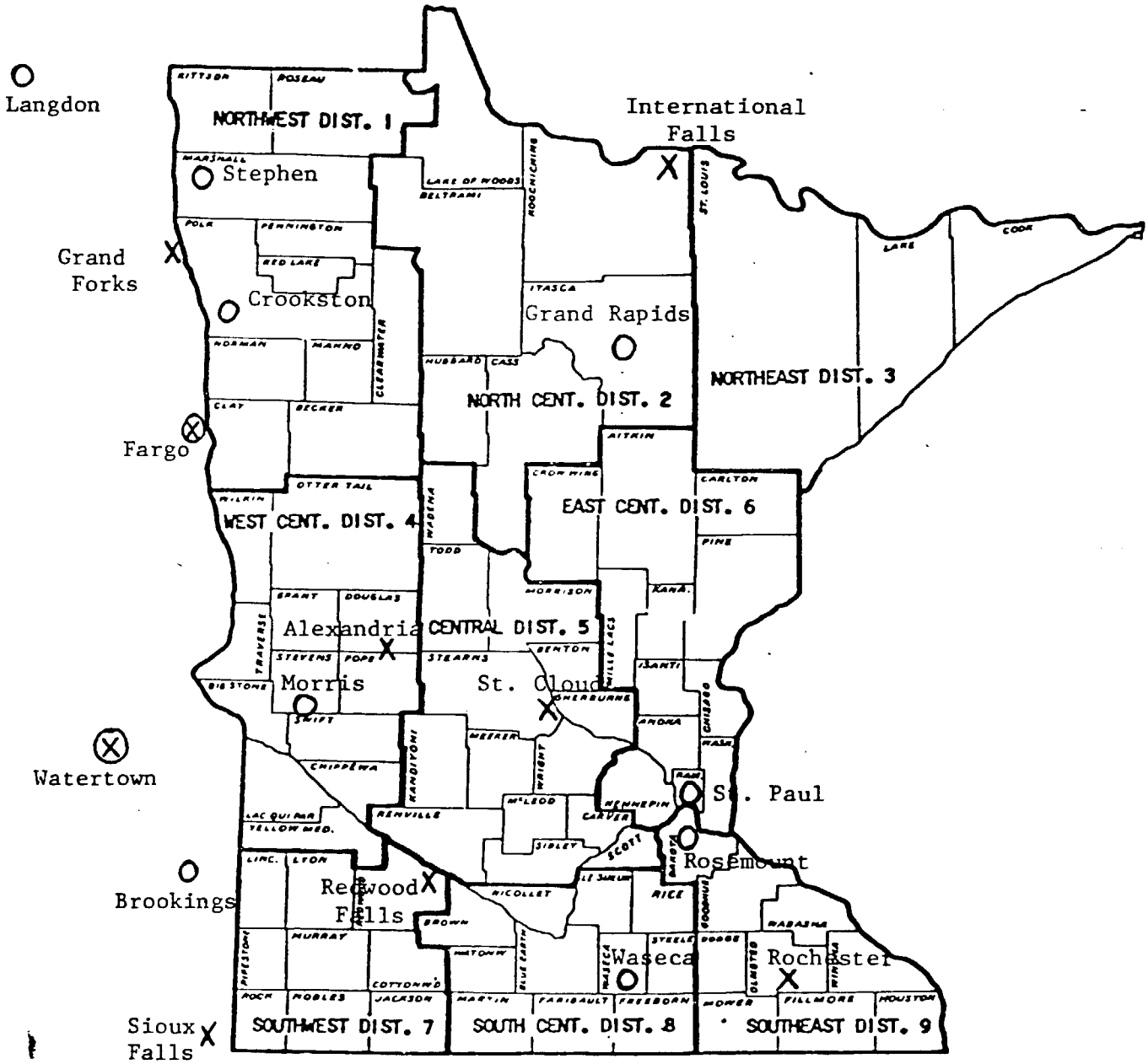


X - Weather Stations

O - Experiment Stations

MAP 2

MINNESOTA



CROP-REPORTING DISTRICTS

X - Weather Stations

O - Experiment Stations

day after day, without calculating any variables. Documentation of this idiosyncracy in the User's Manual would have been helpful.

(2) Two different tables containing soil moisture budget contents on planting day are printed in the output. One breaks down the contents for the six zones, while the other prints out only the total. However, if one adds up the 6 contents from the first table, one will rarely obtain the exact figure in the second table. This is because the first table is printed out at the beginning of planting day, before the VSMB subroutine has run for the day, while the second prints out the contents at the end of planting day, after the running of the VSMB subroutine. Feyerherm used the second table in calculating his WX x variables: We initially used the first table and found my results off by as much as 0.1 or 0.2 bu/acre rather than the much smaller rounding differences shown in Table I.

x x x x x x x x x

V. AVDYA

AVDYA = statewide average differential yielding ability (bushels/acre)

$$= \Sigma(q_K * DYA_K) \; / \; \Sigma \; q_K,$$

where q_K = % of acres in the state planted to variety K, and

DYA_K = differential yielding ability for variety K.

DYA's are defined more completely in "Data Base Documentation For Test Data for KSU Spring Wheat Model," sec. VII.B. Most varieties are compared directly to base variety Thatcher, a variety with a long history of yield evaluations in experimental test plots. DYA_K is merely the difference in yield between the base variety and variety K. Some intermediate standards were used when direct comparisons with Thatcher were nonexistent or too few in number to allow an acceptable variance for the mean difference. A more lengthy discussion of the rationale and choices for intermediates is given later.

Our Sources:

To produce DYA values we used varietal performance trial data on the tapes which Dr. Feyerherm sent us. This is the same data he used; no truly "independent" check data source exists because Dr. Feyerherm contacted most available experiment stations in the two states. The data were obtained from published reports of the experiment stations, and are made available each year. Dr. Feyerherm is in the process of documenting the names and addresses of the station personnel who should be contacted with requests for updates each year.

Performance trial data were available in years prior to 1954 for several stations. Minot and Langdon had the earliest data, back to the early 1930's. Each station varies from another with respect to its date of beginning.

It should also be noted that most of these experiment stations had corresponding weather station data (see Appendix A, "User's Manual" for DYAPGM'80). These same experiment stations served as the source for the plot yield regressions used in original model parameter and coefficient development.

Below is a list of YES sources for percentage of acres planted to individual varieties:

North Dakota--

N. Dakota Wheat Varieties 1970, Ag. Stat. #22, January 1971, published by SRS.

N. Dakota Wheat Historic Estimates 1955-1970, Ag. Stat. #33, October 1979, published by SRS.

N. Dakota Crop & Livestock Historic Estimates 1971-1975, Ag. Stat. #43, October 1978, published by ESCS.

N. Dakota Agricultural Statistics 1980, Ag. Stat. #45, May 1980, published by ESCS.

Minnesota--

Minnesota Agricultural Statistics 1965, March 1965, published by SRS.

Minnesota Agricultural Statistics 1975, August 1975, published by SRS.

In the above sources for N. Dakota there are also varietal percentages available for 1939, 1944, 1949, 1955, and 1957. The later two are of interest as Feyerherm did not know of their existence.

As for Minnesota, our sources did not include varietal planted percentages for 1979, but did include additional years 1939, 1944, 1949, and 1973. The later year, again, was unknown to Feyerherm. Both Minnesota sources overlapped each other in years 1959 and 1964, and a comparison of these reported percentages brought out discrepancies within the State published data. Some errors could have been made because the 1965 published data had varieties reported as percentage of all wheat, while 1975 published data showed varieties reported as percentage of Hard Red Spring Wheat and Durum Wheat, separately. Planted percentages for 1979 were obtained per telephone conservation with Cecil Foss, Head, Crops Section, Minnesota SSO.

N. Dakota publishes varietal planting percentages each May, for the previous year's data, in its Ag. Stat. yearbook. Minnesota, however, collects the data only every few years, and they are not systematically published, though they can be obtained through the Minnesota SSO.

Comparison to Feyerherm's N. Dakota Data:

(1) DYA

When Feyerherm calculated his DYA values he began by running the DYAPGM'80 program for 1969 using experiment station fields in Dickinson, Langdon, Minot, Williston, and Fargo (all in N. Dakota). He then used those DYA values, for all accumulated performance tests up to and including 1969, for his entries in Table 1 of his report "Data Base Documentation for Test Data for KSU Spring Wheat Models" for the years 1954, 1959, 1964 and 1969. After 1969, he ran DYAPGM'80 for each of the years he had data for planted varietal percentage (1970, 1971, 1972, 1973, 1974, 1975, 1978, 1979), and also added performance test data for 22 cooperating farmers' fields (see page 11, Appendix A, User's Manual). This pattern I was able to duplicate, as well as reconstruct DYA values for those varieties needing one or two intermediate standards. YES running of the DYAPGM'80 resulted in the exact same values of DYA_K for all years and all varieties, with only 11 exceptions. These exceptions are noted below:

Year	Variety	F DYA	YES DYA	Year	Variety	F DYA	YES DYA
1964	Lakota	6.91	6.90	1972	Leeds	3.81	3.80
1970	Justin	1.28	1.27	1973	Justin	0.81	0.87
1971	WS 1809	-1.08	-1.07	1974	Justin	0.81	0.87
1971	Leeds	4.00	3.98	1974	WS 1809	0.94	0.95
1972	WS 1809	0.80	0.81	1975	Justin	0.81	0.87
1972	Wells	6.32	6.31				

None of these are discrepancies except the Justin 1973-1975 values. This error was made in transcribing from computer printout to paper. None of these differences should greatly affect AVDYA values for their respective years. However, there are two issues to be discussed here. One is the question of why Feyerherm used DYA values derived using data through 1969 for years prior to 1969 instead of calculating each year's DYA values separately, and the second is the question of what effect would occur if one would select different intermediates from those chosen by Feyerherm (Wells, Mindum, Chris and Waldron)?

In answer to the first question Feyerherm explained that he was most interested in building a data set through 1969 which would serve him for model development. He was concerned about the large variations possible when dealing with the smaller sample sizes available in the early years (1954, 1959, etc. . .). We later verified that these larger variations did actually occur. For the sake of interest we have rerun the DYAPGM'80 for all years separately, plus 1955 and 1957, and calculated the DYA values for all appropriate varieties. Results of these runs are found in Table K and will be discussed later.

With respect to the second question, Feyerherm's main criteria for selecting the proper intermediate varieties was to have some kind of rational scheme that would be simple as well as resulting in lower variability in the DYA values. He did look at a variety of other intermediates, but selected those finally chosen for consistency as well as larger sample sizes and lower variance. Additional time would be necessary to compare the numerous possibilities of intermediate choices and their variances.

(2) % planted acreage/variety.

When we made the initial review of the data, we assumed that these percentages were based on All Wheat planted acreage, including winter wheat. Going through every year we found the data accurate, with minor differences probably due to rounding only. We then reconsidered, and recalculated these percentages based on total Spring Wheat only. Since winter wheat makes up such a small percentage of all wheat in North Dakota, we did not expect to find many changes, which was true. In many cases the original differences were corrected, and our answers more nearly matched Feyerherm's. We later confirmed that Feyerherm used Spring Wheat only for his percentages. YES source percentages are reported in Table K.

Three problems did arise, however. The first occurred when we checked Feyerherm's summation of these percentages in his Table 1. Errors in summing to total % occurred in 1970 (91%, not 94%) and 1971 (95%, not 91%). Using DYA values in his Table 1., we recalculated AVDYA in these two years and found a difference of only 0.1 in each case (in 1970 AVDYA = 3.3, not 3.2, and in 1971 AVDYA = 3.0, not 3.1).

The second problem arose for varieties which did have over 1% of total spring wheat planted acreage and were not included in Feyerherm's Table 1. Some of these he did not include because varietal performance data were either lacking or so few as to provide unstable DYA values (see "Users Manual" for DYAPGM'80, pg. 13). One variety, however, should have been included. In 1978 Cando had 3% of all spring wheat planted acreage, and in 1979 it had 4%. This variety was included in subsequent YES runs of the DYAPGM'80, and is reported in Table K.

The third problem was that of rounding up percentages to 1.0 when actual planted percentages were less than 1.0. At first (1954-1969) Feyerherm did not round any varieties up to 1.0%, though there were many instances when he could have. Starting in 1970, however, his data did include some varieties rounded up to 1.0%, but not all. If he had rounded consistently upward in all years, there would have been an addition of several varieties not now included in his Table 1. (ex. Lark in 1972, Calvin in 1979, Selkirk in 1969, etc.). In order to be consistent, I included all possible varieties with planted percentages greater than 0.50% for all spring wheat in all years in Table K. Also noted in Table K are those variety/year combinations where actual percentage planted is less than 1.0%.

Table K

YES source % planted to variety and computed DYA & AVDYA values (bu/acre) where years prior to 1969 have been calculated separately. Compare to Feyerherm's Table 1 values.

Variety[x]	1954		1955		1957		1959		1964		1969	
	%	DYA	%	DYA	%	DYA	%	DYA	%	DYA	%	DYA
Thatcher	11	0.00	3	0.00	1	0.00	2	0.00				0.00
Rival	4	1.81[t]	1	1.81	1[x]	1.81						1.81
Mida	14	1.63[t]	4	1.56	1	1.23	1[t]	1.21[t]				1.37
Rescue	3	-0.80[t]	2	-0.77	1[x]	-1.27						-2.11
Cadet	3	1.56	2	1.56								1.56
Rushmore	10	1.11[t]	12	1.13	3	0.08	2	0.05[t]				0.01
Redman	1	0.52	1[x]	0.52								0.52
Lee	32	2.26[t]	56	2.56	11	1.86	13	1.39[t]	10[t]	0.96[t]		0.78
Selkirk			4	9.40	56	3.44	58[t]	2.87[t]	13[t]	2.41[t]	1[xt]	1.78[t]
Conley					2	-1.69	6	-1.52[t]				-1.05
Canthatch									2	1.06[t]	1[xt]	0.96[t]
Pembina									9	0.69[t]		0.40
Justin									29[t]	1.85[t]	7	1.48
Crim											2	1.84
Chris											18[t]	2.84
Manitou											11	4.41
Fortuna											11	-1.35
Polk											2	2.47
Waldron											1	1.37
Chinook							1[xt]	-1.56[t]	1[xt]	-1.49[t]		
Mindum	14[t]	2.40[t]	10	2.43	2	2.31	0	2.10[t]	0	1.50[t]	0	1.18
Stewart	3	3.83[t]	1[x]	3.75	1[x]	4.53						3.39
Ramsey					3	4.32	4	3.41[t]				2.70
Langdon					14	4.90	10	3.93[t]	1[xt]	3.76[t]		3.48
Lakota									6[t]	6.79[t]		6.90
Wells									25[t]	6.59[t]	16[t]	6.29
Leeds											25[t]	4.50
YES % & AVDYA	95	1.70	96	2.42	96	3.15	97	2.35	96	3.24	95	3.38
FEYH % & AVDYA	94	0.81					96	1.60	94	3.06	94	3.47

x - Actual percentages are less than 1.0%, but are rounded up to 1.0.
t - Difference exists between Feyerherm value and YES value.

Table K: Continued

Variety	1970		1971		1972		1973		1974		1975	
	%	DYA	%	DYA	%	DYA	%	DYA	%	DYA	%	DYA
Canthatch	1[x]	0.94[t]	1[x]	0.94								
Justin	6	1.27	3	0.86	2	0.81	1	0.87[t]	2	0.87[t]	1	0.87[t]
Crim	1[x]	1.71										
Chris	12	2.55	7	2.10	6	2.08	4	2.12	3	2.12	2	2.12
Manitou	17	3.83	6	3.24	4	2.97	1	3.03	2	3.03	1[x]	3.03
Fortuna	5	-1.13	2	-0.94	2	0.04	1	0.68	1	0.68	1[x]	0.68
Polk	3	1.76	2	0.43	2	0.01	2[t]	0.49	1	0.49	1	0.49
Waldron	19	3.31	45	2.62	36	2.22	38	2.43	34	3.18	30	3.16
Bonanza			1	1.85[t]	2	2.37[t]	2	3.45	1	3.22[t]	1[x]	3.22
WS 1809			1	-1.07[t]	8	0.81[t]	6	1.20	3	0.95[t]	1	1.63
Era							2	15.82	5	14.71	5	13.81
Lark					1[xt]	6.33	6	7.62	6	9.62	1[x]	4.66
Bounty 208					2	9.84	4	9.94	4	9.38	2	7.46
Olaf									3	6.78	11	6.91
Ellar											1	1.81
Mindum	0	1.11	0	1.11	0	1.07[t]	0	1.05	0	1.05	0	1.05
Wells	8[t]	6.35	8	6.35[t]	8	6.31[t]	8	6.43	7	6.43	4	6.62
Leeds	20	4.26	19	3.98	21	3.80	15	3.74	10	3.72	5	3.60
Rolette							4	4.87	13	5.53	10[t]	5.73
Ward									5	9.13	18	7.49
YES % & AVDYA	92	3.31	95	2.97	94	2.91	94	3.88	100	5.18	95	5.40
FEYH % & AVDYA	91	3.30	95	2.97	93	2.88	93	3.91	100	5.18	96	5.41

Table K: Continued

	1978		1979	
	%	DYA	%	DYA
Chris	1[x]	2.12	0	2.12
Waldron	19	3.67	15	3.67
Era	3	12.86	2	12.86
Wared	2	10.97	2	10.97
Olaf	23	7.99	19	7.99
Prodax	2	11.41	3[t]	11.41
Ellar	5	3.00	3[t]	3.00
Kitt	3	8.29	1	8.14
Butte	3	8.90	15	8.03
Solar			1	11.37
Mindum	0	1.05	0	1.05
Wells	1	6.51	1[x]	6.39
Leeds	1	3.14	1	3.02
Rolette	3	4.68	2	4.67
Ward	16	7.68	13	7.67
Rugby	5	7.42	6	7.42
Crosby	3	7.53	3	7.43
Botno	1	4.99	2[t]	4.99
Calvin			1[xt]	5.37[t]
Cando	3[t]	9.26[t]	4[t]	9.09[t]
YES % & AVDYA	94	6.86	94	7.18
FEYH % & AVDYA	91	6.78	90	7.14

(3) AVDYA

YES computed AVDYA values are compared with Feyerherm's AVDYA values below. We computed pre-1969 AVDYA values in two ways: (1) incorporating the YES source planted percentages and DYA values in a manner similar to Feyerherm (DYA values through 1969 used for all years previous to 1969), and (2) using the DYA values of Table K which were derived in each year separately. Both ways incorporated the planted percentages we discovered for 1955 and 1957.

	AVDYA				AVDYA		
Year	FEYH	YES(1)	YES(2)	Year	FEYH	YES(1)	YES(2)
1955	1.0	0.8	2.4	1968	3.4	3.3	3.4
1956	1.1	1.3	2.8	1969	3.5	3.4	3.4
1957	1.3	1.8	3.2	1970	3.3	3.3	3.3
1958	1.4	1.7	2.8	1971	3.0	3.0	3.0
1959	1.6	1.6	2.4	1972	2.9	2.9	2.9
1960	1.9	1.9	2.6	1973	3.9	3.9	3.9
1961	2.2	2.1	2.7	1974	5.2	5.2	5.2
1962	2.5	2.4	2.9	1975	5.4	5.4	5.4
1963	2.8	2.6	3.0	1976	5.4	5.4	5.4
1964	3.1	2.9	3.2	1977	5.4	5.4	5.4
1965	3.2	3.0	3.2	1978	6.8	6.9	6.9
1966	3.3	3.1	3.3	1979	7.1	7.2	7.2
1967	3.3	3.2	3.3				

From these values we can make the following observations:

(1) Prior to 1959 YES(2) values were at least 2.0 to 2.5 times larger than Feyerherm's values. Differences in these years between Feyerherm and YES(1) values are the result of additional percentage data in 1955 and 1957.

(2) Between 1959 and 1969 the large differences between YES(2) and Feyerherm values begin to decrease and then disappeared completely.

(3) After 1969, YES(1) and YES(2) values were identical, and differences between Feyerherm and YES values were never larger than 0.1.

We also calculated the variances of the Feyerherm and YES(2) AVDYA values for years 1954 and 1959. These variances in $(bu/acre)^2$ are as follows:

	FEYH	YES(2)
1954	0.1220	0.3102
1959	0.3778	1.3204

We can see that Feyerherm was correct when he used DYA values calculated through 1969 to produce AVDYA's with smaller variances.

Comparison to Feyerherm's Minnesota Data:

(1) DYA

As in N. Dakota, Feyerherm calculated DYA values for years prior to 1969 by using all performance test data through 1969. After 1969 he again ran DYAPGM'80 for each of the years in which he had planted percentages (1974 and 1979). His data came from experiment station fields in Brookings and Watertown, SD, Langdon and Fargo, ND, and Waseca, St. Paul, Grand Rapids, Rosemont, Morris, Crookston and Stephen, MN.

When we recreated this procedure we verified all of the DYA values exactly except for those in year 1979. In that year all YES source DYA values resulted in discrepancies with Feyerherm values. Although we made subsequent checks and tried out several other possible methods of running the program, we could not find the source of the discrepancy until we called Dr. Feyerherm. As it turned out, in 1979 Dr. Feyerherm included an experiment station in Lamberton, MN which was not documented in his "Data Base Documentation ..." report (see pg. 10). When we added this station in our DYAPGM'80 run, all differences between Feyerherm and YES results disappeared.

Again as in N. Dakota, we recalculated DYA values in the years prior to 1969 using the performance test data through each year separately. We also calculated DYA values for 1973. The results of these runs are shown in Table L.

(2) % planted acreage/variety

Several problems surfaced when we compared YES source percentages with Feyerherm's data. In 1974 Feyerherm reported 3% planted to Justin, but our sources made no mention of Justin at all in 1974. Instead we discovered varieties Waldron and Bounty 208 to have 3% each when rounding to the nearest percent (both actually had under 3%).

Even more confusing were large discrepancies which occurred in other years where check data existed. Due to the previously mentioned published discrepancies, it is difficult to find the source of departure.

Table L

YES source % planted to variety and computed DYA and AVDYA values (bu/acre) where years prior to 1969 have been calculated separately. Compare to Feyerherm's Table 2 values.

Variety	1954		1959		1964		1969		1973		1974		1979	
	%	DYA	%	DYA	%	DYA	%	DYA	%	DYA	%	DYA	%	DYA
Rushmore	15	4.69*						3.25						
Lee	70*	7.21*						5.56						
Selkirk			97*	9.09	54*	7.61*	4*	6.70						
Pembina					10*	4.70*		4.42						
Justin					26*	3.94*		3.60						
Chris							50	6.68	12	5.68	6*	5.41	0	4.78
Manitou							20*	7.33						
Polk							11	7.70						
Era									40	16.47	63*	15.64	62	14.17
WS 1809									10	11.29	9	10.78		
Lark									17	3.11	7	5.52		
Waldron									8	7.49	3*	8.04*		
Bounty 608									6	7.54	3*	8.04*		
Wared													4	12.33
Olaf													9	11.24
Kitt													6	11.57
Butte													3	14.69
Solar													5	11.33
Mindum					0	3.29*	0	2.82	0	3.01				
Lakota					4*	10.86*		11.68						
Wells					4*	9.52*	4	10.14						
Leeds							5	7.51						
YES % & AVDYA	85	6.77	97	9.09	98	6.55	94	7.13	93	10.73	91	13.21	89	13.47
FEYH % & AVDYA	81	5.13	91	6.70	95	6.30	92	7.13			85	13.24	89	13.47

* - Difference exists between Feyerherm value and YES value.

Feyerherm said that he calculated his percentages based on spring wheat only, as we did. Taking percentages as published by Minnesota in 1965 for years 1959 and 1964, the most important YES-Feyerherm discrepancies are listed below:

Year	YES%	Feyerherm %	Variety
1954	70	66	Lee
1959	97	91	Selkirk
1964	26	22	Justin

Listed below are the discrepancies in 1965-1975 Minnesota published figures, based on planted percentages of all spring wheat only:

Year	1965%	1975%	Variety
1959	97	93	Selkirk
1964	54	48	Selkirk
1964	26	30	Justin

A complete listing of all percentages for each variety/year from YES sources is in Table L.

(3) AVDYA

YES computed AVDYA values are compared with Feyerherm's AVDYA values below. As in North Dakota we computed AVDYA values in two ways: (1) incorporating all YES source planted percentages and DYA values in a manner similar to Feyerherm (DYA values through 1969 used for all years previous to 1969) and (2) using the DYA values of Table L, which were derived in each year separately. In both methods we used the planted percentages discovered for 1973.

	AVDYA				AVDYA		
Year	FEYH	YES(1)	YES(2)	Year	FEYH	YES(1)	YES(2)
1955	5.4	5.5	7.3	1968	6.9	6.9	7.0
1956	5.7	5.8	7.7	1969	7.1	7.1	7.1
1957	6.1	6.1	8.2	1970	7.1	7.1	7.1
1958	6.4	6.4	8.6	1971	7.1	7.1	7.1
1959	6.7	6.7	9.1	1972	7.1	7.1	7.1
1960	6.6	6.6	8.6	1973	7.1	10.7	10.7
1961	6.5	6.4	8.1	1974	13.2	13.2	13.2

Year	AVDYA FEYH	YES(1)	YES(2)	Year	AVDYA FEYH	YES(1)	YES(2)
1962	6.5	6.3	7.6	1975	13.2	13.2	13.2
1963	6.4	6.1	7.1	1976	13.2	13.2	13.2
1964	6.3	6.0	6.6	1977	13.2	13.2	13.2
1965	6.5	6.2	6.7	1978	13.2	13.2	13.2
1966	6.6	6.4	6.8	1979	13.5	13.5	13.5
1967	6.8	6.7	6.9				

From these values we made the following observations:

(1) Prior to 1959, YES(2) values were about 35% greater than FEYH values.

(2) Between 1959 and 1969, YES(2) and FEYH value differences narrowed to almost zero.

(3) After 1969 YES(2) and YES(1) values were identical, and the only difference between YES and FEYH values occurred in 1973 due to the additional percentage data available to us.

As in N. Dakota, we calculated the variance of AVDYA values for the FEYH method and the YES(2) method. These variances in $(bu/acre)^2$ for 1954 and 1959 are below:

	AVDYA FEYH	YES(2)
1954	0.4812	0.9314
1959	0.9533	2.9300

Again Feyerherm was correct; variances are smaller when using data through 1969 as compared to using data only through 1954 or 1959.

Location of Experiment Stations:

Maps 1 and 2 show the location of the experimental stations used in DYAPGM'80. The Red River District CRD's for both Minnesota and North Dakota are fairly well covered by experiment stations (Langdon, Fargo, Stephen, Crookston, Morris, Watertown, Brookings). These stations do seem appropriate, and Feyerherm used them because of the similarity in weather conditions over that entire area. The rest of the CRD's in these two states are less fully covered.

VI. EE_HLOSS

EE_HLOSS = STYLD_H * EEF/(100-EEF)

= Yield loss (bu/acre) due to rust,

where EEF = % loss in yield due to rust.

Our Sources:

We contacted David Long, Plant Pathologist, USDA Cereal Rust Laboratory, University of Minnesota, St. Paul, MN. He sent us the following publications containing the rust data we needed for 1955-1979:

1955-1976 - Estimated Losses Caused by Rust in the Small Grain Cereals in the United States - 1918-76, March 1978, published by ARS.

1977 - Preliminary Estimated Losses from Rust in 1977, March 14, 1978, published by USDA Cereal Rust Laboratory.

1978 - Preliminary Estimated Losses from Rust in 1978, March 19, 1979, published by USDA Cereal Rust Laboratory.

1979 - Preliminary Estimated Losses from Rust in 1979, March 5, 1980, published by USDA Cereal Rust Laboratory.

These data are gathered and published each year in breakdowns of Durum, Other Spring, and Winter wheat. In the historic publication covering data from 1918-1976, however, the data were published by All wheat only. The data are published at the state level only; no CRD or county level estimates are derived. They are published each March for the previous season's crop.

In the previously mentioned historic publication, an overview of the data collection methods is discussed. No actual samples are taken: the "surveys" are not probability-type surveys. The estimates are mostly subjective with a small amount of supplemental research plot data used over the past 15 years. The data collection methods otherwise have stayed mostly consistent since they were begun in 1918. All states are estimated, although not all since 1918. North Dakota and Minnesota data sets do go back through 1918.

Comparison to Feyerherm Data:

Since Dr. Feyerherm acquired his rust loss data from the same laboratory, we expected to find no differences between his data and YES sources. All years for both states were checked. Minnesota data did match up exactly; N. Dakota data showed two differences:

Year	% Rust Loss Feyerherm	YES
1963	2	6
1964	3	2

We do not know why these differences exist. The 4 bu/acre difference in 1963 may significantly affect final yields.

VII. Join Point for Trend Terms

In the report, "Preliminary Testing of KSU Spring Wheat Model, " Feyerherm described the method he used to determine the join point between two linear trend terms. He states that he used model 1, which includes identified technology, and only the years 1955 to 1969. Models were fit and the mean square error (MSE) estimated while successively changing the join point from 1957 to 1967. The join point associated with the smallest mean square error was stated to be 1963 for North Dakota and 1968 for Minnesota.

Our results, following the same method and data provided by Feyerherm, yielded a slightly smaller MSE using 1964 as the join point in North Dakota. Also, we noted that the search region was expanded somewhat in determining a 1968 join point for Minnesota.

VIII. Estimates of Parameters Used in Test Years

The values we obtained for the model parameters, running models 1 and 2 with and without Trend 2, were the same as those reported by Feyerherm in his Preliminary Testing report. However, we are not sure what rule he used to determine whether the Trend 2 coefficient should be zero or non-zero. We initially thought he used a t-test on the Trend 2 coefficient and if the P value exceeded α, another model would be fit excluding Trend 2. If an α of 0.10 were used, this rule would work for models 1 and 2 in North Dakota and model 2 in Minnesota. However, for model 1 in Minnesota, there are discrepancies using this rule. For example, for data through 1969, the P value is 0.0488, yet Feyerherm used a model fit omitting Trend 2. For data through 1978, the P value is 0.12. However, the model fit included Trend 2.

IX. Comparison of Predicted and Actual Yields

We confirmed the values Feyerherm gave (correcting the model 2 results for the 1972 test year in Minnesota as he requested) for predicted yields. Using his all wheat USDA yields to obtain differences, Feyerherm reported the following results over the 1970-79 test years in bushels/acre.

	Bias	MSE	RMSE
North Dakota			
Model 1	1.2	8.23	2.87
Model 2	0.15	6.79	2.60
Minnesota			
Model 1	1.18	28.51	5.34
Model 2	0.68	35.82	5.98

The same results converted to quintals/hectare are:

	Bias	MSE	RMSE
North Dakota			
Model 1	0.81	3.72	1.93
Model 2	0.10	3.07	1.75
Minnesota			
Model 1	0.79	12.89	3.59
Model 2	0.46	16.20	4.02